The influence of magnetic field on the superconducting properties and the BCS-BEC crossover in systems with local fermion pairing

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We present results from our study of the superconducting properties and the BCS-BEC crossover in the spin-polarized attractive Hubbard model and its extensions. We consider both the ground state properties and the case of non-zero temperature, in two and three dimensions. The methods used include the BCS-Stoner-type mean field approximation, the Kosterlitz-Thouless scenario, the self-consistent T-matrix method in (GG_0)G_0 and (GG)G_0 schemes and the strong coupling expansion. We first discuss the weak-coupling limit at T=0, with s-wave and d-wave pairing symmetries in 2D. Then, we move on to finite temperature properties analyzed in the framework of the Kosterlitz-Thouless transition. We also discuss the BCS-BEC crossover - in 2D and 3D, with and without mass imbalance, in the ground state and at finite temperatures. Among the most important results is the existence of a homogeneous magnetized superconducting phase in 3D, for strong attraction and in the dilute limit. This phase is a specific superfluid state consisting of a coherent mixture of local pairs (hard-core bosons) and excess spin-up fermions (Bose-Fermi mixture).